

**MARKER LIGHTS FOR
WIRELESS DOORBELL TRANSMITTERS
AND OTHER DEVICES**

5 BACKGROUND OF THE INVENTION

1. Field of the Invention:

10 The present invention relates to low level luminaires particularly for use marking the location of doorbell buttons, driveway edges and the like, and more particularly relates to a battery powered luminaire providing a useful battery life of one or more years.

2. Description of the Problem:

15 Since the introduction of wireless doorbells, customers have requested a lighted button feature to assist in locating the doorbell button in the dark. Lacking connection to line electrical power, providing such a feature has proven impractical to achieve with even the smallest incandescent sources, since the power demands of incandescent bulbs exhaust the typical battery sizes usable in these products within hours, or days, at best. Larger batteries could increase
20 incandescent battery life, but these are costly and their bulk is not appropriate in the application of a doorbell button. Early, non-high intensity type, LED light sources, while operable for far longer periods than incandescent sources, still cannot operate at the very low current levels required to obtain desirable battery life objectives of one year or longer and still emit useful levels of light.

25 Other products could benefit from a battery powered, long life light source suitable for use in a wireless doorbell. Self-contained battery powered chimes hardwired to a door mounted push button are very common in Europe, although somewhat rare in North America. Lighted buttons are a desirable feature here as well, but cause the batteries in the chime to become quickly exhausted. Thus battery chime systems have not included a lighted button. Presently, incandescent bulbs and
30 low efficiency LED light sources are used in lighted buttons, but they consume far too much current to provide acceptable battery life in battery powered chimes.

Battery life can also be extended for an LED device by causing the LED to blink on and off. This can also serve to attract attention to the device. For a residential application however, most consumers do not want to have a blinking red LED marking their doorbell, driveway, or sidewalk. Operating the red LED on a continuous basis may be more attractive to consumers, but would require
5 substantially more power.

Reflector based markers and some types of landscape lights could also benefit from a long life battery powered luminaire. Roadside, bicycle and driveway reflector products are very effective when a bright source light shines directly on them. Otherwise, such reflectors are ineffective. A
10 self-lighted marker has the advantage of being visible without an external source of light directed on it, so that it is visible to walkers, joggers and bicyclists at night. It is also useful in driving situations where the location marked would be outside the normal field of headlights. Roadside reflectors have been proposed that have made use of solar charging systems for batteries. Rechargeable batteries can be bulky though and the solar cells and recharging circuits can add
15 substantially to the relative cost of the product. Solar cells must be placed in locations that receive direct sunlight during some part of the day, and, as a consequence, may not work in the desired location, such as the side of a house facing away from direct sunlight or on a shaded porch. During winter at high latitudes very little sunlight is received, reducing the effectiveness of these products.

20 Under conditions of darkness, it does not require much light output to make an object visible. The human eye has great light intensity adaptability. The differences in eye sensitivity between conditions of bright sunlight (photopic vision) and fully night adapted vision (scotopic vision) can vary by a factor of 25,000 and instances of adaptation up to a factor of 1,000,000 times has been documented. Multiple mechanisms within the eye provide this adaptability, some responding
25 quickly to changing light conditions, e.g. pupil dilation, and some slowly, e.g. maximum rod sensitivity, so that fully night adapted vision is not achieved for up to 30 minutes. The implication of this is that levels of light, useless under normal indoor lighting conditions, can become useful under conditions where one can anticipate people will have adapted to darkened conditions. The spectrum of light generated makes a difference to the minimum output in lumens required for human
30 perception. Generally people can see broad spectrum or white light more readily than they can see red or violet light.

Visible spectrum applications of light emitting diodes have long included simple status indicators and dynamic power level bar graphs. Display applications have grown in number and super bright LEDs are used in various automotive and traffic signal applications. Super bright LEDs are extremely efficient in terms of the percentage of input power converted to visible radiation compared with devices previously known. This is one reason they are favored for applications requiring the output of high intensity light. Super bright LED devices are available which emit any one of a variety of colors, or which emit broad spectrum radiation. Some super bright LEDs also work over broad ranges of drive currents and emit low intensity light at low drive currents and with low power consumption. These LEDs can exhibit efficiencies at these power levels comparable to the high efficiencies achieved at the much higher power levels at which they are normally intended to operate. United States Patent 6,140,776 to Rachwal teaches a flashlight that exploits this property in one application.

The terms white light and broad spectrum radiation are used broadly in this patent. Ideally, the present invention would apply to LEDs which emit a spectrum blend of visible light optimized to produce a physiological response in a normal human eye at an absolute minimum intensity level. The terms are thus used in the sense of any spectrum output producing greater perceived brightness than monochrome radiation generated at the same energy level.

SUMMARY OF THE INVENTION

The invention provides a marker luminaire combining a super bright LED and a low energy drive circuit to promote long battery life. Such a luminaire comprises a housing and a lamp disposed in the housing capable of producing light visible to a partially darkness adapted human eye. A minimal current is selected to produce enough light to be seen at the desired distances. A light scattering element is optically associated with the lamp to make the marker light visible across a wide viewing angle and thereby indicate the location of the housing. An electrical energization circuit provides the minimal current to the lamp. The electrical circuit may further comprise a photosensitive element responsive to high and low ambient light conditions for cycling operation of the LED. A replaceable electrical power cell is positioned in the housing in the electrical energization circuit as a power source.

Additional effects, features and advantages will be apparent in the written description that follows.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of
10 illustrative embodiments when read in conjunction with the accompanying drawings, wherein:

Fig. 1 is a partial cutaway view of a wireless doorbell transmitter in accord with the invention;

Fig. 2 is an alternative wireless doorbell transmitter in a partial cutaway view;

Fig. 3 is another alternative wireless doorbell transmitter in a partial cutaway view;

Fig. 4 is yet another alternative wireless doorbell transmitter in a partial cutaway view;

Fig. 5 is a detailed circuit schematic for the wireless doorbell transmitters of **Figs. 1-4**;

Fig. 6 is a perspective view in partial cut-a-way of a portable marker luminaire;

Fig. 7 is a circuit schematic for the luminaire of **Fig. 6**;

Fig. 8 is perspective view in partial cut-a-way of a driveway marker luminaire;

Fig. 9 is a perspective view in partial cut-a-way of an illuminated address sign;

Fig. 10 is a circuit schematic for the luminaires of **Figs. 8 and 9**;

Fig. 11 is a circuit schematic usable with the luminaires of **Figs. 12** and **13**;

Fig. 12 is a perspective view in partial cut-a-way of coin cell marker luminaire; and

5 **Fig. 13** is a perspective view of a light pull chain luminaire.

DETAILED DESCRIPTION OF THE INVENTION

Due to the nature of the human eye, monochrome LEDs operating at the same efficiency as
10 a broad spectrum or white light LED require substantially more current than do the broad spectrum
LEDs to achieve the same perceived brightness level. Since contemporary monochrome super bright
LEDs do not exhibit substantially greater efficiencies in light generation compared to broad spectrum
LEDs, super bright white LEDs may be operated at a current which is small fraction of their rated
current for the diode, and at a lower current than a monochrome LED, and still provide a level of
15 illumination useful as a marker for darkness adjusted vision. At the time this patent was written,
broad spectrum LEDs are preferred for the marker applications described herein. However, were
technical developments to lead to monochrome or limited spectrum LEDs exhibiting much higher
efficiencies than white LEDs, than such devices might also produce perceptible light at a lower
current than a white LED and come to be preferred for many of these applications.

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A luminaire used for marking the location of an object need not be particularly bright under
circumstances where it can be expected that a person looking for the object will have partially
darkness adapted vision. Contemporary, super bright, white LEDs rated at 15 to 20 milliamps can
be operated in ranges extending from just below 5 milliamps to a few microamps and produce
25 perceptible light. Extraordinarily long battery life for a luminaire can be achieved at these current
levels. Endurance can be further extended by turning the LEDs on and off based on the need for
light. For example, an ambient light sensitive control circuit may be used to turn off the luminaire
during daylight. Using the low-level white LED approach and a daylight sensor, it is possible to
obtain battery life in the range of 1-3 years for some applications using typical small lithium coin
30 cells.

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Figs. 1-4 illustrate in a series of cut-a-way views battery operated wireless doorbell transmitters in which an embodiment of the invention is incorporated. In **Fig. 1** a wireless doorbell transmitter **10** comprises a plastic case **12** which in turn encloses a printed circuit board **14**. Printed circuit board **14** mounts circuitry **16** used to transmit an encoded RF signal when a switch **18**, which is positioned directly behind a push-button **20**, is closed by the action of pressing the push-button. Circuitry **16** is further arranged so that the current used to generate the RF signal passes through a light emitting diode (LED) **22** causing it to illuminate, and resulting in visible confirmation that the RF transmission has occurred. The RF transmission current would typically be several milliamps. If the LED **22** is a high efficiency type typically known as Super Bright, the LED will light brightly enough to be easily seen even on a sunlit day.

Circuitry **16** includes a cadmium sulfide (CdS) light sensor **24** for causing a low level current to pass through the LED **22** when the ambient light level is below a predetermined threshold. If LED **22** is a super bright type of LED that exhibits high efficiency light generation at low current levels, a "glow-in-the-dark" illumination level can be achieved using a very low LED drive current. The combination of a very low glow-in-the-dark current level and the ability of the CdS light sensor **24** to turn the LED **22** off during the day minimizes the total current required from battery **26** and results in long battery life. Wireless doorbell transmitter **10** emits no light when ambient light is sufficient to allow the unit to be seen without aid, emits a low level of light to mark its location during times of darkness, and emits high intensity light, visible during daylight, in response to use to indicate operation. A single type A23 alkaline cell is sufficient to provide a year or more of service. The small battery size in turn permits use of a case **12** roughly comparable in size to conventional doorbell button cases.

A light sensor opening **28** through the bottom portion of case **12** allows ambient light to enter the case and fall on the CdS light sensor **24**. A clear lens can be placed in the light sensor opening **28** if sealing the case **12** is considered desirable. Alternatively, case **12** can be made from a translucent or transparent material that allows a useful amount of ambient light to pass through and fall on the CdS light sensor **24**.

LED **22** is positioned very near, or partially within, and optically coupled to, a translucent

ring 30. When activated, either by the switch 18 or the CdS light sensor 24, LED 22 emits light which is coupled into the ring 30 and produces a glow which surrounds push-button 20. The translucent material of ring 30 scatters the light and distributes it throughout the ring, which is visible across a broad angle. At night, when the push-button 20 has not been pressed, the ring 30 glows at a low level from light from the LED. A normal eye that has achieved some degree of night adaptation can readily see the ring 30 and identify the push-button 20. Upon push-button 20 being pressed the ring glows at a second, substantially higher level, indicating that the device is operating.

Fig. 2 shows a cut-a-way view of an alternative embodiment, battery operated, wireless doorbell transmitter 40. Wireless doorbell transmitter 40 is similar to the transmitter shown in Fig. 1, except that no glow ring 30 is present and switch 18 has been offset to allow placement of LED 22 directly behind a push-button 34. Push-button 34 is preferably made from a translucent material diffusing any light emitted by LED 22. A portion 36 of push-button 34 extends over the switch 18 so that the switch is activated when the push-button is depressed. Case 32 is modified as against the case in Fig. 1 to eliminate provision for the glow ring 30.

LED 22 is positioned directly behind the translucent push-button 34 in such a manner that the light from the LED will be directed onto the push-button. When activated either by the switch 18 or the CdS light sensor 24, light from the LED 22 illuminates the push-button 34. The push-button 34 can be clear, translucent, or faceted. Translucent, or faceted materials, diffuse or refract the light from LED 22 and distribute it about push-button 34. Even when made of clear materials, the cylindrical shape of button 34 provides sufficient scattering of light to make the button visible across a wide angle. Under low ambient light conditions, when push-button 34 has not been pressed, the push-button glows at a low level illuminated from LED 22. For pushbuttons 34 made from a clear material, light emitted from the LED 22 is directly visible through the push-button. In each case, low level light is visible to a darkness acclimated eye.

Fig. 3 is a cut-a-way illustration of yet another embodiment of a battery operated wireless doorbell transmitter 42. The transmitter is similar to the transmitters shown in Figs. 1-2, except that LED 22 now protrudes through the front of case 36. Push-button 38 is preferably made of an opaque material and is positioned directly over switch 18. Transmitter 42 is generally similar to the

transmitter described with reference to **Fig. 1**. LED **22** itself includes a semiconductor device embedded in a clear plastic material, which is shaped to provide some light scattering.

Fig. 4 is a cut-a-way view of still another embodiment of a battery operated wireless doorbell transmitter **44** incorporating a super bright LED and providing two distinct levels of illumination, one lower level for marking the location of the transmitter under low ambient light conditions and another much higher level for indicating operation of the transmitter. The transmitter **44** is similar to those of **Figs. 1-3**, however, it incorporates a rectangular push-button **48** and a case **49** modified to incorporate the rectangular push-button. A back light reflector **46** distributes light from LED **22** evenly to the backside of push-button **48**. Light reflector **46** is positioned behind push-button **48** and the LED **22** is positioned below the reflector and oriented to cast light upward toward the light reflector and the push-button in order to illuminate the push-button's back face. The light pattern created by LED **22** is typically a cone that starts at the tip of the LED and is symmetrical about the LED's central axis as it expands away from the LED's tip. This central axis of the cone of light extends parallel to and behind the push-button **48**, aligned with the direction of elongation of the push-button. The light cone expands away from the LED **22**, intersecting the push-button **48** where the light is diffused by the translucent material of the push-button causing the push-button to glow. However, direct illumination from LED **22** is not of uniform intensity since the back surface of the push-button **48** is not a uniform distance from the LED. Much of the light emitted by LED **22** does not directly strike push-button **48** and would not add to the brightness of the push-button without reflector **46** from a wide angle due to the light scattering properties of the push-button.

Reflector **46** is preferably arranged and shaped so that much of the light from LED **22** that does not directly strike the push-button **48** will strike the light reflector and be reflected back onto the push-button. This reflected light adds to the brightness of push-button **48** and also reduces the intensity of light variations across the face of the push-button. Light reflector **46** is usually a flat surface, but can also be a curved or angled surface. The shape and angle of the light reflector's surface can be set in conjunction with the position and angle of the LED **22** to minimize variations in light intensity across the surface of the push-button **48**. At night, when the push-button **48** has not been pressed, the push-button will glow at a low illumination level in response to the light from the LED **22** and reflected off of light reflector **46**. For an eye that has achieved some degree of night

adaptation, the illumination level is sufficient that push-button **48** can be readily located.

An advantage of the doorbell systems so far discussed is that they can be used on any chime system, including battery less systems, and is universally applicable. Retailers should prefer selling
5 a universal product compared with differentiated products suitable only for certain doorbell systems.

Fig. 5 is a circuit schematic for the wireless doorbell transmitters of **Figs. 1-4**. Encoder and RF circuitry **58** along with the RF antenna **60** are shown only in block diagram form and can be implemented in a multitude of ways that are well known in the art. Coded signals broadcast by
10 encoder and RF transmitter **58** and antenna **60** are received by a receiver and wireless doorbell chime unit **64** over an antenna **62**.

Power is supplied to the illumination control circuitry **16** and to encoder and RF transmitter circuitry **58** from a battery **26**, which preferably comprises a single A23 style alkaline cell. A
15 momentary switch **18** connects, when closed, the encoder and RF transmitter circuitry **58** to battery **26** resulting in an encoded RF transmission. Switch **18**, battery **26**, LED **22**, and encoder and RF transmitter **58** are connected in series. When encoder and RF transmitter **58** is operating, it draws several milliamps and, as a result, LED **22** glows brightly. When momentary switch **18** is open, encoder and RF transmitter **58** are disconnected from the battery **26** to prolong battery life.

With momentary switch **18** open, any current flowing through LED **22** must be sunk by a bipolar transistor **52**. Battery **26**, LED **22**, resistor **56** and an NPN bipolar transistor **52** are connected in series. Conduction of the transistor **52** is controlled by a voltage divider circuit connected between the positive and negative terminals of battery **26** and comprising a resistor **54** and the CdS light
25 sensor **24**. The base of transistor **52** is connected to tap the voltage between resistor **54** and the CdS light sensor **24**.

CdS light sensor **24** is a light sensitive resistor whose resistance depends inversely on the amount of light that falls on it. When ambient light levels are relatively high, the resistance of the
30 CdS light sensor will be low and the current flowing through resistor **54** will be diverted around the base-emitter junction of transistor **52**. In other words V_{BE} will be low and transistor **52** will be in cut

off. With transistor **52** in cut off, no current flows through LED **22**. During daylight hours, the primary current flow is through resistor **54**, which is chosen to have a resistance on the order of 10 Mohms. This high value resistance limits current drawn from the battery **26** to a minimal level, prolonging the battery's life. As ambient light levels decrease, the resistance of the CdS light sensor **24** increases, and the base current into transistor **52** likewise increases until transistor **52** begins operating. With transistor **52** conducting, current flows through LED **22** and resistor **56**. A value for resistor **56** is chosen to limit the current to a low level, preferably about 5 micro amperes.

LED **22** is of a type commonly known as Super Bright and is further of a type that maintains its light producing efficiency even at very low current levels. In addition, the LED should be of a type that produces relatively white or broad spectrum light, which has a perceived brightness greater than that produced by a monochrome LED of equal intensity. One particular LED that meets these requirements is part number NSPW310BS available from Nichia America Corporation. Even at a very low forward current, this type of LED provides enough illumination to be visible to eyes that are at least partially dark-adapted.

Fig. 6 is a cut-a-way perspective view of a battery-operated marker light **66**. Marker light **66** provides low level illumination for one year or more on three AAA alkaline cells forming a battery **68** (one cell is shown). The illumination level is not intended to be useful for photopic vision, but rather to provide a useful illumination level for eyes that have achieved some level of night adaptation. Under these conditions (scotopic vision), enough illumination is provided to clearly mark walls, doorways, or other objects. If the eyes are fully night adjusted, enough illumination is provided to carry out simple tasks without requiring any additional lighting.

A plastic case **70** encloses a printed circuit board **72** that contains circuitry **74** which uses a CdS light sensor **76** to turn the marker light **66** on or off in response to ambient light conditions. Plastic case **70** also encloses the batteries **68** that supply power for the circuitry **74** and a super bright LED **78**. The circuitry **74** passes a low level current through the LED **78** when the ambient light level is below a predetermined threshold. If a Super Bright LED of the type that maintains its efficiency at low current levels is used for LED **78**, a "glow-in-the-dark" illumination level can be achieved using very low current levels. Very low current levels, combined with the ability of the

CdS light sensor **76** to turn off the LED **78** during the day, minimize the current that is required from the Battery **68**. Battery lifetimes of a year or more can be achieved using three AAA alkaline cells, allowing use of a compact package.

5 A light sensor opening **80** in the front of case **70** allows ambient light to enter the case and fall on the CdS light sensor **76**. A clear lens could be placed in the light sensor opening **80** if an open hole is undesirable. Alternatively, case **70** can be made from a translucent material that allows ambient light to pass through and fall on the CdS light sensor **76**.

10 Case **70** further includes a light reflecting surface positioned behind a translucent lens **84**, which in turn forms a substantial portion of the front of the case. LED **78** is positioned within case **70** above and just behind translucent lens **84**, but forward of light reflecting surface **82**. LED **78** is oriented to cast light downwardly both onto the light reflecting surface as well as directly on the translucent lens **84**. The pattern of light created by LED **78** is typically a cone with its point at the
15 LED's tip that expands symmetrically about the LED's central axis in a direction away from the LED. Where the cone of light intersects the translucent lens **84**, the lens scatters the light causing the lens to glow and to become visible from a wide band of viewing angles relative to the case **70**. However, the glow is not of a uniform intensity since the translucent lens **84** has an arcuate shape and further because various areas of the lens are differently spaced from LED **78**. Much of the light
20 emitted by LED **78** does not directly strike lens **84** and thus does not add directly to the brightness of the lens.

 Much of the light from the LED **78** that does not directly strike the translucent lens **84** strikes the light reflecting surface **82** and is reflected back onto the lens. Light reflecting surface **82** is
25 illustrated here as being a flat surface. Appropriate shaping and variation of the slope of surface **82**, for example by introducing curves thereto or by changing its angle of repose, can be done to vary the angle of incidence light falling thereon from LED **78** and even the distribution of light. Similarly, local changes to the reflectivity of surface **82** can reduce light intensity variations across the face of the lens **84**, at some loss of efficiency. The shape and angle of the light reflecting surface
30 **82** can be set in conjunction with the position and angle of the LED **78** to minimize variations in light intensity across the surface of the translucent lens **84**. Under low ambient light conditions

translucent lens **84** glows in response to the light from LED **78** and from the light reflecting surface **82**. After the eye has achieved some degree of night adaptation, the illumination level is sufficient to be useful as a marker light.

Fig. 7 is a circuit schematic for battery powered marker light **66** of **Fig. 6**. Battery **68** preferably comprises 3 AAA cells and is connected into a circuit that controls illumination of LED **78** in response to ambient light levels. Attached in series across the cathode and anode of battery **68** are a resistor **86** and a CdS light sensitive resistor **76**, the resistance of which depends inversely on the level of ambient light.

Operation of marker light **66** is light sensitive. When ambient light levels are relatively high, the resistance of the CdS light sensitive resistor **76** is low and current flowing through resistor **86** is diverted around the base-emitter junction of transistor **88**. Transistor **88** remains off and no current flows through LED **78**. Resistor **86** is chosen to have a resistance such that current drawn from battery **68** by circuit paths including the resistor (i.e. the path including resistor **86** and light sensitive resistor **76** and the path formed by resistor **86** and the base to emitter junction of npn transistor **86**) is extremely low, with the result that battery life is little effected. As the ambient light level decreases, the resistance of the CdS light sensitive resistor **76** increases, increasing the base current of transistor **88**. Transistor **88** turns on and causes current to be sunk at the transistor's collector.

Current sunk at the collector of transistor **88** is drawn through a circuit path formed by LED **78** and resistor **90**. Resistor **90** has a value chosen to limit this current to a low level as required to achieve reasonable battery life, but sufficient to provide illumination for scotopic vision. For a fully charged battery **68**, the initial glow-in-the-dark current is set to about 250 micro amperes, but gradually decreases as battery **68** discharges. LED **78** is of a type commonly known as Super Bright that maintains its light producing efficiency even at very low current levels. In addition, if the LED is of a type that produces relatively white or broad spectrum light, the perceived brightness will be greater than that produced by a monochrome LED of equal intensity. One particular LED that meets these requirements is part number NSPW310BS available from Nichia America Corporation. Even at low forward currents, this type of LED provides enough illumination to be useful for eyes that are at least partially dark-adapted.

Fig. 8 is a partial cut-a-way view in perspective of a battery powered driveway marker **92**.

The driveway marker provides low levels of illumination for one year or more based on a battery **110** comprising four alkaline D cells. Marker **92** comprises a translucent, light scattering, rigid tube **94** which is mounted on one face of a substantially flat, disk-like base **96**. Extending from the opposite face of base is a positioning spike **98**, which allows the marker to be planted in the ground along a driveway or sidewalk. Tube **94** glows from internally generated light emitted by an LED **100**. A portion or all of tube **94** may be hollow in order to enclose an internal structure that houses the battery **110** and the electronic circuitry needed to control LED **100**. LED **100** is of the type commonly know as super bright and glows visibly at a current as low as 4 or 5 milliamps, which is substantially below the LED's rated output. Such a current level can be supported by battery **110** for over a year if drawn only at night. Light emitted by LED **100** shines upwardly from the LED's position in a battery housing cover **102** in the lower portion of tube **94**. The intensity of light at any particular point along the surface of tube **94** is usually insufficient for photopic vision, but is visible to eyes which have adapted to night vision. Under low ambient light conditions (scotopic vision), enough illumination is provided to make tube **92** clearly visible.

A battery housing **106** located in the lower portion of the tube **94** encloses battery **110**, a printed circuit board and associated circuitry **104** and a light sensitive resistor **108**. Housing **106** is closed at its upper end by a cover **102**. LED **100** is mounted on the printed circuit board **104** and extends upwardly from housing **106** and through the center of cover **102**. Light sensitive resistor **108** is also mounted on the printed circuit board **104** along with circuitry to control the current supplied to the LED **100**. An opening (not shown) in the housing cover exposes the light sensitive resistor **108** to ambient light conditions reaching the sensor through the tube **94**. The housing cover **102** and housing **106** are cooperatively threaded to allow mounting of the cover to the housing. Contacts within housing **106** and on the bottom of the printed circuit board **104** connect battery **110** to the circuitry on the board.

When compared with landscape lights, the driveway marker lights of the present invention exhibit the advantage of being self-contained. As such, installation of the lights product is very simple. This is especially important because driveway markers are often located at points that are

the most remote within the yard from a source of power. Compared with solar products which also eliminate the hassle of wiring installation, this product is not dependent on sunlight to recharge batteries, which is a severe limitation for solar technology and it is also less costly because there are no solar panels, nor rechargeable batteries.

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An alternative application of the driveway marker electronics is a battery powered address sign 112, illustrated in **Fig. 9**. Address sign 112 is a flattened rectangular case 119 which has a translucent, light scattering display area 118 forming a portion of a front face of the case and a battery enclosure 122 located over the display area. Within case 119, both behind and to one side of display area 122, is an LED 116. LED 116 is oriented to direct light across the case 119 behind the display area 118. LED 116 is mounted on a circuit board 114, which may also be used to support a light sensitive resistor (not shown). Along a back wall of case 119, opposite the translucent display area 118, is a reflective surface 120. Reflective surface 120 provides for a more even distribution of light from LED 116 across the display area 118. A battery 124 comprising four size D alkaline cells is located in battery enclosure 122.

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Fig. 10 is a circuit schematic for driveway marker 92 and suitable for use with address sign 112. Power is supplied to glow-in-the-dark circuitry by battery 110. The control circuitry provides two series connected resistors, resistor 126 and light sensitive resistor 108 connected between the cathode of battery 110 and its anode. The base of transistor 128 is connected between resistor 126 and resistor 108. The CdS light sensitive resistor 108 in effect controls the base current, and thus the conduction state of an npn transistor 128. The resistance value for resistor 108 depends inversely on the amount of light that falls the resistor/sensor. When ambient light levels are relatively high, the resistance of resistor 108 is low and the current flowing through resistor 126 primarily passes by resistor 108 to ground. When ambient light levels are low, the resistance value of resistor 108 increases, and base current is directed into transistor 128, driving the transistor into conduction. The resistance value chosen for resistor 126 is high enough, on the order of one megaohm, that the current drawn by any path including resistor 126 is negligible in terms of the current's effect on battery life.

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Transistor 128 in turn controls a current source feeding LED 100. When transistor 128 is

conducting, current flows through a pair of series connected diodes **132** and **134**, which connect the base of pnp transistor **136** to the cathode of battery **110**. The current from diode **134** passes further through resistor **130** and from the collector to the emitter of transistor **128**. The forward bias drop across diodes **132** and **134** provides a substantially fixed emitter to base bias for transistor **136** driving the transistor into conduction. Transistor **136**, when on, functions as a current source feeding LED **100**, which is connected by one terminal to the collector of the transistor. A resistor **138** connected between the emitter of transistor **136** and battery **110**, limits the amount of current sourced to a level consistent with long battery life.

The value for resistor **138** is chosen to limit this glow-in-the-dark current to a low level as required to achieve reasonable battery life, e.g. about 4 milliamps. LED **100** is of a type commonly known as Super Bright. In addition, if the LED is of a type that produces relatively white light, the perceived brightness will be greater than that produced by a monochrome LED of equal intensity. One particular LED that meets these requirements is part number NSPW315BS available from Nichia America Corporation. This type of LED provides enough illumination to be useful for eyes that are at least partially dark-adapted. Using the low-level white LED approach, it is possible to light the luminaire and still achieve typical battery life of one year or more. In combination with a daylight sensor, battery life can be further extended.

For applications where duty cycling as a function of ambient light is undesirable, for example areas which are usually dark absent artificial light, the LED drive circuitry may advantageously be simplified. Referring to **Fig. 11**, a simplified LED **140** drive circuit is taught. A battery **144** comprises a single coin cell to energize super bright LED **140** through a simple series circuit including the cell, a resistor **142** and the LED. The value of resistor **142** is selected so that the current through LED **140** is substantially below the rated value of the LED, as described above for the photo sensitive circuits. Specific component values depend upon the application.

Fig. 12 depicts a coin cell marker light **150** which may incorporate either the circuit of **Fig. 11**, or that of either **Figs. 5** or **12**, modified for the lower power application. Where the circuit of **Fig. 11** is used, a single CR2450 lithium cell is used in series with a resistor chosen to limit forward current to about 70 micro amperes and which gradually decreases as the battery discharges.

Alternative circuit arrangements, such as that of **Fig. 10**, can be applied which will source current at nearly a steady state value until the battery approaches exhaustion. The LED is preferably a broad spectrum type such as the NSPW315BS supplied by Nichia America Corporation.

5 Coin cell marker light **150** provides a year or more of low level illumination. Coin cell marker light **150** comprises a semi-transparent, faceted, or translucent case top **168** which is roughly bowl shaped and which attaches around the lip of a plate shaped case bottom **162**, allowing the case top to be rotated on the case bottom. Case top **168** operates to scatter light impinging on its interior surface. If an optional light opening **166** is provided and the case bottom **162** is attached to a wall or fixture, case top **168** can be rotated to better position the light opening for receiving external light
 10 for illuminating a photosensitive element. *Directing*
~~for illuminating a photosensitive element.~~
an object or surface.

Mounted within case top **168** is a printed circuit board **156**. Attached to the bottom of the printed circuit board **156**, between the board and the case bottom **162**, are battery cell retainer clips
 15 **160**, which are arranged in a semicircle and which are spaced to grasp a coin cell **164** pressed in the semicircle. A resistor **158** is also shown attached to the bottom face of printed circuit board **156**. Mounted above the printed circuit board **156** is a light reflector **154**, and above the light reflector is disposed the LED **152**. LED **152** casts light directly onto the translucent case top **168**, and onto reflector **154**, which reflects scattered light onto the case top. Case top **168** may be colored,
 20 playfully shaped, or include an image for projection onto a surface.

Referring now to **Fig. 13**, another application of the LED energization circuit of **Fig. 11** is illustrated. Here a super bright LED **172** is fitted within a pull chain grip **170** formed from a decorative case top **178** and a snap on case bottom **180**. Grip **170** hangs from a chain **182**. Fitted
 25 into the upper portion of case bottom **180** is a battery cell holder **174**, which also provides an attachment location for the current limiting resistor (shown in **Fig. 11**) and a coin cell **176**. LED **172** attaches to the bottom of the battery holder **174**. Case bottom **180** may provide light scattering.

The invention provides cordless and inexpensive apparatus having long battery life for
 30 marking the location of objects and enabling them to be found under conditions of darkness.

While the invention is shown in only a few of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit and scope of the invention.